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[54] DEVICE FOR SPRAYING LIQUID

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[30] **Foreign Application Priority Data**

Aug. 7, 1969 Japan 44/62014

[52] **U.S. Cl.** **239/296,** 239/299, 239/599, 239/601

[51] **Int. Cl.** **B05b 1/28**

[58] **Field of Search**...239/419.3, 296, 297, 298, 299, 239/599, 601, 421, 400, 405, 299, 300

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[57] **ABSTRACT**

A method of spraying liquid in a flattened, conical shape through a spray gun having a circular air slit for injecting compressed air and a circular liquid slit disposed adjacent to and around the circular air slit for atomizing the liquid by injecting compressed air from one or more pairs of air jets from outside of the slits and from opposite dispositions with respect to the axis of the spray stream in the inward and tangential direction to the sectional circle of the spray stream of the liquid, thereby expanding the spray of conical liquid particles in one diametrical direction of the sectional circle of the spray stream so as to flatten the sectional circle. This method is accomplished by a spraying gun having one or more air jets disposed outside the central spraying portion of the liquid and opposite with each other with respect to the center of the spraying portion which is formed with a circular air slit for injecting the compressed air and a circular liquid slit disposed adjacent to and around the air slit for atomizing the liquid.

12 Claims, 18 Drawing Figures

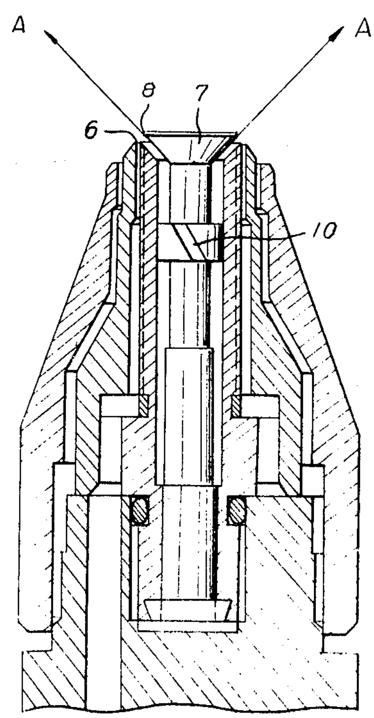

Fig. 1
PRIOR ART

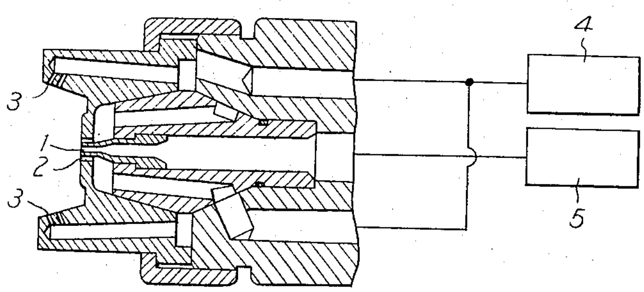

Fig. 2
PRIOR ART

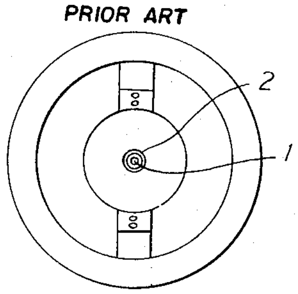

Fig. 3a

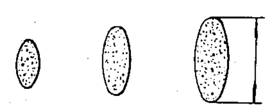

Fig. 3b

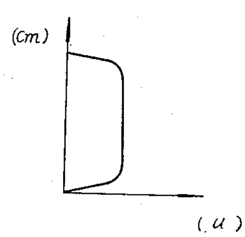

Fig. 4

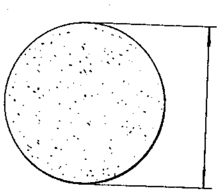

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Fig_5_

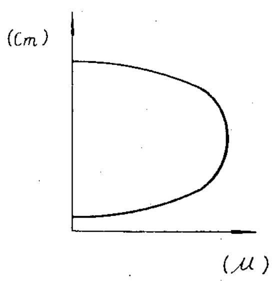

Fig_6_

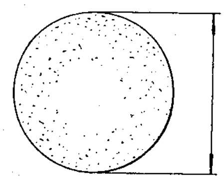

Fig_7_

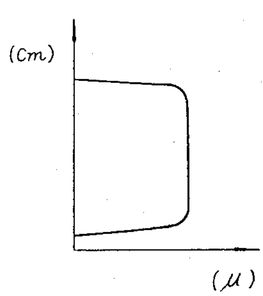

Fig_8_

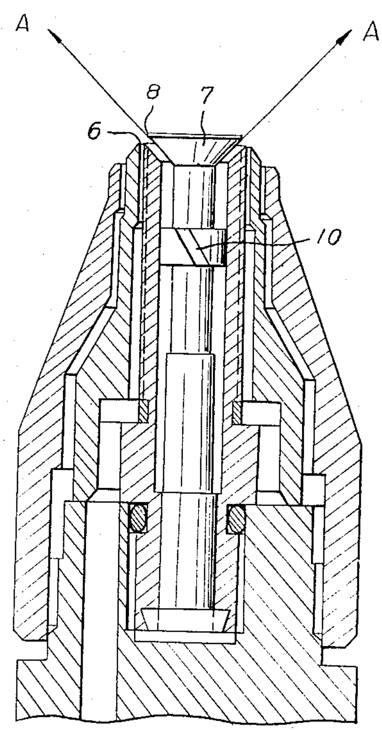

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Fig_9_

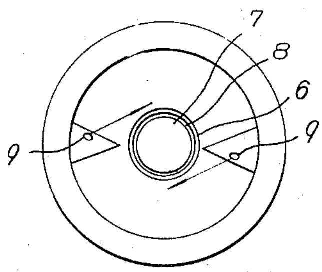

Fig_10_

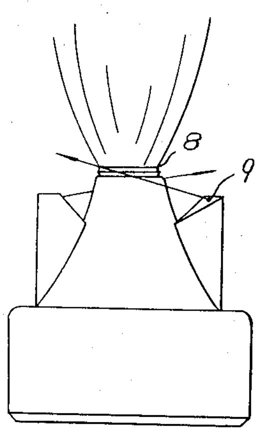

Fig_11_

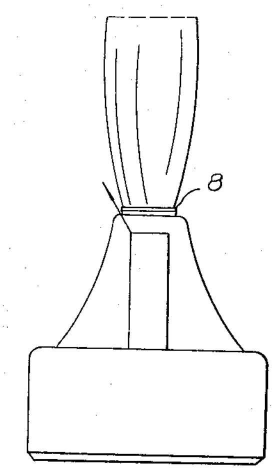

Fig_13_

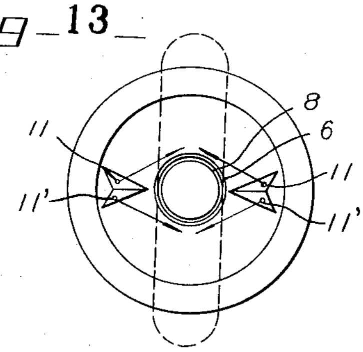

Fig_12_

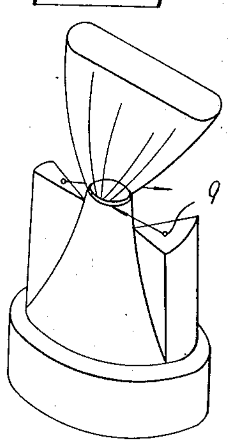

Fig_14_

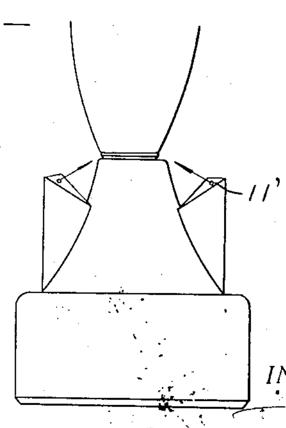

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Fig. 17

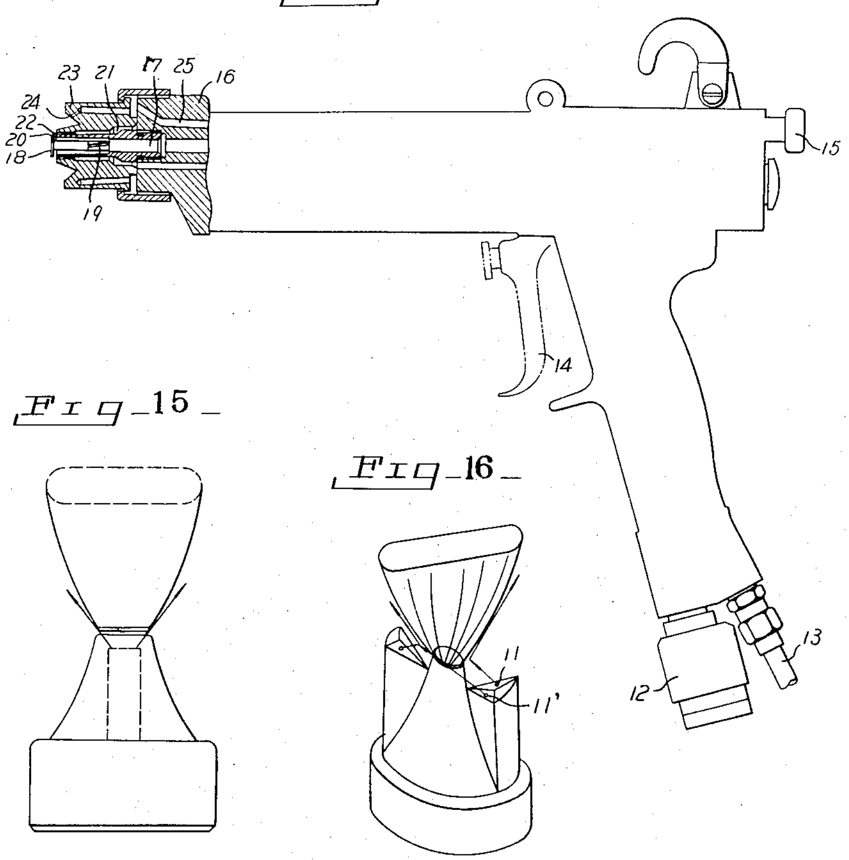

Fig. 15

Fig. 16

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DEVICE FOR SPRAYING LIQUID

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for spraying a liquid such that the cross-sectional shape of the spray is substantially in the form of a flattened ellipsoid.

In order to spray coat a liquid evenly and efficiently onto an article, it has been found desirable that the spray stream have a generally elliptical cross-sectional configuration. This elliptical pattern should be well defined and should be free of any "over-spray" which might be caused by particles blown from the spray stream by jets of air used in forming the desired shape of the spray. Furthermore, the liquid particles forming the spray stream should be so finely divided that spattering of the liquid on the surface being coated is prevented. The spray should also be evenly discharged from the spraying apparatus so that no portion of the pattern becomes so thin as to leave streaks, nor so heavy as to cause a rippled appearance in the finished product. It is therefore imperative that the spray stream be properly shaped and consist of a substantially homogeneous pattern of finely divided particles.

To reduce the manufacturing costs of spray equipment and to reduce the expense of the spraying operation, the air pressure and accordingly, the air consumption rate should be kept at a minimum so that the parts or components of the equipment, including the compressor, the dehumidifier, and the oil and dust filters can be kept at a minimum size. The force or energy of the spray should be kept at a minimum so as to minimize the degree of spattering of the liquid and to minimize the degree of over-spraying of the surrounding surfaces and surrounding work areas. Another advantage of minimizing the force or energy of the spray is to permit the accumulation of an electrostatic charge on the spray particles, thereby obtaining better adhesion due to Coulomb's forces.

Conversely, it is desirable to maximize the quantity of sprayed liquid per unit time so that the spraying operation can be performed as quickly and efficiently as possible without deteriorating the atomizing action. In order to achieve a maximum quantity of sprayed liquid per unit time, it has now been proposed to use an atomizing spray head in which a circular liquid outlet aperture is disposed approximately concentric to a circular compressed air outlet aperture. These relative configurations permit the liquid to be atomized and the spray pattern to leave the spraying apparatus in a generally conical or tulip shape.

In order to accomplish the desired dispersion and shaping of the spray stream, it has now been proposed to atomize the liquid leaving the sprayer head with one or more pairs of air jets by injecting compressed air into the stream in a tangential direction to the perpendicular cross-section of the spray stream. The tangential air spray acts to elongate the spray cross-section along one diameter so as to form a flattened elliptical shape.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method of spraying a liquid, such as paint, so as to increase the quantity of liquid sprayed per unit time and to coat the liquid evenly on the article being coated by expanding the cross-section of the spray in one diametrical direction.

It is another object of this invention to provide apparatus for spraying a liquid, such as paint, in a generally flattened ellipsoidal shape of atomized particles.

According to one aspect of the present invention, there is provided a method of spraying liquid in an elliptical pattern by injecting air in tangentially opposed directions at diametrically opposed positions to a tulip-shaped spray having a circular cross-section.

According to another aspect of the present invention, there is provided apparatus for spraying liquid, such as paint, in an elliptical pattern comprising a spray head portion formed with a circular, elliptical or polygonal air slit for injecting compressed air and a circular, elliptical, or polygonal liquid slit disposed adjacent to and around the circular air slit for atomizing the liquid, and one or more pairs of air jets disposed outside of the slits and in opposed positions with respect to the center of the slits for injecting compressed air in an inward and tangential direction to the spray stream so as to elongate the cross-section of the spray stream to a substantially flattened ellipsoidal shape.

Other features and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a longitudinal partial sectional view of a conventional spray head portion of a spray gun and associated equipment shown in schematic form;

FIG. **2** is an end view of the spray head portion shown in FIG. **1**;

FIG. **3***a* is a cross-sectional view of preferred spray streams from a spray gun;

FIG. **3***b* is a schematic graph showing the relationship between the length and thickness of a preferred spray stream of liquid;

FIG. **4** is a sectional view of a conventional spray stream from a spray gun;

FIG. **5** is a schematic graph showing the relationship between the diameter and thickness of the spray stream shown in FIG. **4**;

FIG. **6** is a sectional view of a spray stream in which the center portion thereof is starved of liquid particles;

FIG. **7** is a schematic graph showing the relationship between the diameter and thickness of the spray stream shown in FIG. **6**;

FIG. **8** is a cross-sectional view of a spray head portion used in the spray gun constructed in accordance with the present invention;

FIG. **9** is an end plan view of a spray head portion constructed according to the present invention;

FIG. **10** is a front view of the spray head portion shown in FIG. **9**;

FIG. **11** is a side view of the spray head portion shown in FIG. **9**;

FIG. **12** is a perspective view of the spray head portion shown in FIG. **9**;

FIG. **13** is a plan view similar to FIG. **9**, but showing another embodiment of the present invention;

FIG. **14** is a front view similar to FIG. **10**, but showing the embodiment of FIG. **13**;

FIG. **15** is a side view similar to FIG. **11**, but showing the embodiment of FIG. **13**;

FIG. **16** is a perspective view similar to FIG. **12**, but showing the embodiment of FIG. **13**; and,

FIG. **17** is a longitudinal partial sectional view of one example of a spray gun used with the spray head portion constructed in accordance with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

For the clear understanding of the present invention, the spray head portion of a conventional spray gun will hereinafter be described with reference to FIGS. **1** and **2**, wherein the conventional spray gun generally comprises a spray head having a small liquid outlet aperture **1** disposed in the center of the spray head for discharging a liquid from a liquid supply source **5**. A circular air aperture **2** is generally disposed adjacent to and concentric with the liquid outlet aperture **1** for emitting compressed air from a compressed air source **4**, and atomizing the liquid into finely-divided particles. One or more pairs of air jet apertures **3** are disposed adjacent to the liquid outlet aperture **1** beyond the perimeter of the circular air aperture **2** and directed radially toward the liquid outlet aperture **1**. The air jet apertures **3** emit a compressed air stream into the liquid ejected from outlet aperture **1** to cause the resulting liquid stream to take on the generally ellipsoidal configuration as shown in FIG. **3***a*.

In operation of the spray head portion thus constructed, the spray stream of the atomized liquid particles from the liquid outlet aperture **1** and circular air aperture **2** takes on the configuration of an ellipsoid having a flattened cross-section.

One problem with the apparatus of FIGS. **1** and **2** is that the spraying quantity of liquid per unit time is relatively small and it is difficult to spray the liquid evenly and in finely-divided particles.

In order, however, to increase the spraying quantity of the liquid per unit time and to spray the liquid evenly and in finely divided particles, a spray head portion as illustrated in FIG. **8** has been proposed so as to atomize the liquid and to outwardly expand the atomized liquid particles and generally comprises a cylindrical hollow air chamber **10** axially formed in the spray head portion and opened at one end of the spray head portion with an air stream expanding element **7** inserted into the hollow chamber **10** for forming a circular air slit **8** for expandingly spraying the liquid by injecting compressed air, thus forming the liquid particles in a conical or tulip-shaped spray with a circular liquid slit **6** disposed adjacent to and around the circular air slit **8** for atomizing the liquid. One problem with the apparatus disclosed in FIG. **8** occurs as the result of increasing the quantity of liquid sprayed per unit time from the spray head, since the pressure inside of the conical or tulip-shaped spray is diminished as the quantity per unit time of sprayed liquid increases. The pressure inside of the conical or tulip-shaped spray will be reduced to essentially vacuum due to the injection of the air stream from the air slit **8** with the result that the expanded conical spray is drawn radially inwardly such that the diameter of the sprayed particles in section becomes smaller than that of the original conical shape resulting in collapse of the conical shape to essentially a tulip-shaped spray. The atomized stream of liquid particles sprayed by such a structure cannot be flattened by the conventional air jet holes constructed in the manner disclosed in accordance with FIGS. **1** and **2**.

In coating an article with a spray coating apparatus, either the article can be moved while the sprayer remains fixed, or the sprayer may be moved while the article remains fixed. In either instance, the spray of atomized liquid particles has a circular cross-section, as shown in FIG. **4**, the thickness of the coating will be unevenly varied over the surface, as shown in FIG. **5**. In order to overcome this disadvantage, it has been proposed to spray the liquid so as to purposely cause a degree of depletion or create a starved area of liquid particles in the center portion of the spray configuration, as shown in FIG. **6**, such that a relatively even coating thickness can be obtained, as shown in FIG. **7**.

It has been found that such a spray head sprays a large quantity of liquid per unit time and that the spraying speed of the liquid particles is decelerated as a result of the resistance of the air with the result that no spattering occurs when the liquid particles strike the surface being coated.

It has, however, been found to be quite difficult to always maintain a uniform distribution of liquid particles sprayed onto a surface using a spray gun, as previously described. In other words, it is difficult to always maintain an even distribution of the liquid particles when the spray has a circular cross-sectional configuration, even if the liquid is atomized into the stream in such a manner as to cause a depletion of liquid particles in the center of the spray pattern.

It has been found, however, that the amount of liquid sprayed per unit time from the spray head illustrated in FIG. **8** may be increased by rotatably mounting the spray head onto the spray gun so as to be rotatable about the central axis of the gun. Rotation can be provided by use of a drive shaft attached to the spray head portion.

Referring now to FIGS. **9** through **12**, which illustrate one embodiment of a spray head portion of a spray gun constructed in accordance with the present invention, wherein the spray head portion comprises essentially the same structure as illustrated in FIG. **8** including an air stream expanding element **7** inserted into a hollow chamber (not shown) for forming a circular air slit **8** which expands the liquid spray by injecting compressed air so as to form the liquid particles into a conical shape, and a circular liquid slit disposed adjacent to and around the circular air slit for atomizing the liquid. A pair of air jet holes **9** are disposed outwardly of the air and liquid slits **8** and **6**, and in opposed positions with respect to the center of the slits for injecting air jet streams in inward and tangential directions of the sectional circle of the sprayed liquid particles. These air jet holes **9** may be formed on a pair of projections constructed as shown in the Drawings, and each having an upper face tapered radially and axially inward and in a tangential direction with respect to the sectional circle of the sprayed liquid particles.

In operation of the spray head portion as described, the air jet streams are injected from the pair of air jet holes **9** in a radially and axially inwardly tapered direction with respect to the axis of the spray gun and in the tangential direction of the sectional circle of the sprayed liquid particles, as shown in FIG. **9**, a turning force is applied to the sprayed liquid particles, as shown in FIG. **10**, with the result that the conical or tulip-shaped sprayed liquid particles are flattened and expanded in the direction passing through the air jet holes **9**, as shown in FIG. **12**, and are contracted in the direction perpendicular to the direction passing through the air jet holes **9**, as shown in FIG. **11**. These air jet streams may be injected through a pair of pipes (not shown) disposed outside of the air and liquid slits **8** and **6** and in opposite positions with respect to the center of the slits and so directed as to inject the air jet streams in inward and tangential direction of the sectional circle of the sprayed liquid particles.

The velocity of the air jet streams may be varied by changing the diameter of the air jet holes **9**. Since the air jet uses the same source of compressed air as the circular air slits **8**, the respective pressure may be adjusted thereby.

Referring now to FIGS. **13** through **16**, in which there is illustrated a second embodiment of the spray head portion of the spray gun constructed in accordance with the present invention, the spray head portion consists basically of the same elements as that illustrated in FIG. **9** including the air stream expanding element **7** inserted into the hollow chamber (not shown) for forming a circular air slit **8** for expandingly spraying the liquid by injecting the compressed air to form the liquid particles in a conical shape, and a circular air slit for atomizing the liquid. Two pairs of air jet holes **11** and **11'** are disposed outwardly of the air and liquid slits **8** and **6** and in opposite positions with respect to the center of the slits for injecting air jet streams in inward and opposed tangential directions with respect to the sectional circle of the sprayed liquid particles. These air jet holes **11** and **11'** may be formed on a pair of projections constructed as shown in the Drawings, and each having a pair of upper faces radially and axially inwardly tapered in both tangential directions of the sectional circle of the sprayed liquid particles.

An operation of the spray head portion thus described, if the air jet streams are injected from both pairs of air jet holes **11** and **11'** in the radially and axially inwardly tapered directions with respect to the axis of the spray gun and in both tangential directions of the sectional circle of the sprayed liquid particles, as shown in FIG. **13**, a pair of turning forces act with each other at the intermediate, as shown in FIG. **13**, such that the conical or tulip-shaped sprayed liquid particles are flattened and expanded in the direction perpendicular to the direction passing through the intermediate between the air jet holes **11** and **11'**, and are contracted in the direction passing through the intermediate between the air jet holes **11** and **11'**, as shown in FIGS. **13** through **16**.

The embodiment as illustrated in FIGS. **13** through **16** provides a wider expanded width spray pattern than that that is produced by the embodiment as disclosed in FIGS. **9** through **12**, wherein a single pair of holes are utilized.

Although the two pairs of air jet holes **11** and **11'** are preferably provided on both tapered faces of the trapezoidal projection which are inclined inwardly and in tangential directions of the sectional circle of the sprayed liquid particles, these air jet streams may be injected from two pairs of pipes (not shown) disposed outwardly of the air and liquid slits **8** and **6** and in opposed positions with respect to the center of the slits and so directed as to inject the air jet streams inwardly and tangentially of the sectional circle of the sprayed liquid particles. Furthermore, the air jet holes may be so provided on the flat face of the projections as to direct the air jet streams in the manner as previously described. Although the angle of the air jet holes in relationship to the tangential direction of the sectional circle of the sprayed liquid particles and the size of the air jet holes may not always be the same, but the air jet holes which are disposed on opposite projections but facing in the same tangential direction are preferably of the same size and positioned at the same angle.

The principle employed by the operation of the air jet streams of the spray head essentially breaks the vacuum produced in the center of the conically-shaped sprayed liquid particles as a result of the air jet streams being injected into the conical spray.

For safety purposes, and to prevent the occurrence of sparks between the high voltage spray head portion and the grounded article, the spray head portion should be formed from an electrically resistant substance containing electroconductive particles. For example, the solid element may be made of bakelite containing electro-conductive particles interspersed therein. Alternatively, the solid element may be made of partial stripes of electrically resistant substances, so as to form two or more charge regions at one end of the element for electrostatically charging the liquid being sprayed. In this instance, the elements may be connected to a high voltage power source. Good results have been obtained where the element has a resistance of approximately 50 to 200 megohms per c.c. when measured with a 1,000 volt meter. This electrically resistant element, therefore, prevents spark ignition of the spray, even when high voltages are applied between the spray head portion and the article, yet it permits the creation of a good electrostatic field in order to effectively electrostatically charge the liquid particles.

Reference is now made to FIG. **17**, in which there is illustrated the spray head of the present invention in combination with a spray gun device. The spray gun includes a conduit **12** for feeding paint to the spray head portion, a conduit **13** for feeding compressed air to the spray head portion, a trigger **14** for feeding the paint and compressed air from the conduits **12** and **13** to the spray head portion, an adjusting valve **15** for adjusting the pressure of the compressed air and a spray head **16**. The spray head **16** includes a cylindrical hollow air chamber **17** formed axially within the spray head portion and opened at one end of the spray head portion. An air stream expanding element **18** is inserted into the hollow chamber **17** for forming a circular air outlet aperture **20** for expandingly spraying the liquid by injecting compressed air to form a spray of conical or tulip-shape having a circular cross-section. A circular liquid aperture **22** is disposed adjacent to and around the circular air outlet aperture, whereby the liquid is atomized by the air spray. The element **18** has a guide passage **19** provided on the central axis for spirally feeding the compressed air. This element also has a disc provided on its end which is perpendicular to its axis. A liquid chamber **21** is provided around the air chamber **17**.

The disc of the air stream expanding element **18** is preferably over 3 millimeters in diameter. Using this structure, a tulip-shaped or conical spray is formed from the circular liquid outlet aperture. The direction of the sprayed liquid particles forming the conical shape is preferably at an angle of 45° with respect to the axis of axially inward air stream expanding element **18**.

The spray head portion further comprises a pair of projections **23**, each having a top face tapered radially and axially inward and positioned such that the jet stream is directed tangentially to the cross-section of the liquid spray, as shown. A pair of air jet apertures **24** are located on the projections **23**, and a conduit **25** is provided from the adjusting valve **15** to the circular air outlet aperture **20** for introducing the compressed air from the source of the compressed air through the sprayer conduit **13**, the spray head conduit **25**, and the air outlet aperture **20**.

In operation of the spray gun of this construction, FIG. **14** is manually activated so that compressed air is fed through conduit **13** into air chamber **17**, through the circular air outlet aperture **20**. Simultaneously, a liquid, such as paint, is fed through the conduit **12**, into liquid chamber **21**, and through the circular liquid outlet conduit **22**. Also simultaneously, air jet streams are formed by drawing compressed air through adjusting valve **15**, into air conduit **25** and through air jet apertures **24** such that the jet streams are emitted radially and axially inward with respect to the axis of the spray gun and in a tangential direction to the cross-section of the liquid spray, as shown in the previous Figures of the Drawings.

It should be readily understood from the foregoing description that since the conical or tulip-shaped spray is formed by the introduction of air and liquid emitted from the circular air and liquid outlet apertures, the spray is elongated along one direction and contracted along its perpendicular diameter such that the quantity of liquid sprayed per unit time is increased, yet permitting the liquid to be coated evenly on the surface.

Even if the spray head of the present invention is used for electrostatically coating a liquid onto a surface, the velocity of the sprayed liquid particles is decelerated by the particular structure of the spray head such that spattering of the coating does not result.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A device for spraying liquid in a pattern having a generally elliptical cross-section comprising a spray head portion including a circular air slit for injecting compressed air, a circular liquid slit disposed adjacent to and around said circular air slit for atomizing said liquid, and a pair of air jet apertures disposed outwardly and rearwardly of said slits and in opposed positions with respect to the center of said slits for injecting compressed air in a generally inward and tangential direction to the sectional circle of the sprayed stream of liquid particles so as to contact said sprayed stream of liquid particles substantially in the plane of said slits.

2. A device as set forth in claim **1**, wherein said air and liquid slits are essentially elliptical.

3. A device as set forth in claim **2**, wherein said air and liquid slits are essentially polygonal.

4. A device as set forth in claim **1**, wherein said air jet apertures comprise two pairs of air jet apertures disposed outwardly of said air and liquid slits and in opposed positions with respect to the center of said slits for injecting air jet streams inwardly and in opposed tangential directions with respect to the sectional circle of the sprayed liquid particles.

5. A device as set forth in claim **3**, wherein said pair of air jet apertures are formed on a pair of projections integrally constructed with the spray head portion and each including an upper face tapered radially and axially inward and in a tangential direction to the sectional circle of the sprayed liquid particles.

6. A device as set forth in claim **5**, wherein said pairs of air jet apertures are formed on a pair of projections integrally constructed with the spray head portion and each including a pair of upper faces tapered radially and axially inward and in opposed tangential directions to the sectional circle of said sprayed liquid particles.

7. A device as set froth in claim **5**, wherein the angle of the air jet apertures disposed in opposed tangential directions are different, and the angle of the air jet apertures disposed in the same tangential direction are the same.

8. A device for spraying liquid in a pattern having a generally elliptical cross-section comprising a generally cylindrical hollow chamber formed axially in a spray head portion and opened at one end of said spray head portion, an air stream expanding element inserted in said hollow chamber for forming a circular air slit for expandingly spraying liquid by injecting compressed air to form the liquid particles in a generally conical shape, a circular liquid slit disposed adjacent to and around said circular air slit for atomizing said liquid, and a pair of air jet apertures disposed outside of and rearwardly of said air and liquid slits and in opposed positions with respect to the center of said slits for injecting air jet streams in a direction inwardly and tangentially to the sectional circle of the sprayed liquid particles so as to contact said sprayed stream of liquid particles substantially in the plane of said slits.

9. A device for spraying liquid in a pattern having a generally elliptical cross-section comprising a cylindrical hollow chamber formed axially in a spray head portion and opened at one end of said spray head portion, an air stream expanding element inserted within said hollow chamber for forming a circular air slit for expandingly spraying the liquid by injecting compressed air to form the liquid particles in a generally conical shape, a circular liquid slit disposed adjacent to and around said circular air slit for atomizing said liquid, and a pair of air jet pipes disposed outwardly and rearwardly of said air and liquid slits and in opposed positions with respect to the center of said slits and so disposed as to inject the air jet streams in-wardly and tangentially to the sectional circle of the sprayed liquid particles so as to contact said sprayed stream of liquid particles sub-stantially in the plane of said slits.

10. A device as set forth in claim **9**, wherein said air jet apertures are provided on the flat faces of said projections so as to direct said air jet streams.

11. A device for spraying liquid in a pattern having a generally elliptical cross-section comprising a cylindrical hollow chamber formed axially in a spray head portion and opened at one end of said spray head portion, an air stream expanding element inserted within said hollow chamber for forming a circular air slit for expandingly spraying liquid by injecting compressed air to form liquid particles in a generally conical shape, a circular liquid slit disposed adjacent to and around said circular air slit for atomizing said liquid, and two pairs of air jet apertures disposed outwardly and rearwardly of said air and liquid slits and in opposed positions with respect to the center of said slits for injecting air jet streams inwardly and tangentially of the sectional circle of said sprayed liquid particles so as to contact said sprayed stream of liquid particles substantially in the plane of said slits.

12. A device for spraying liquid in a pattern having a generally elliptical cross-section comprising a cylindrical hollow chamber formed axially in a spray head portion and opened at one end of said spray head portion, an air stream expanding element inserted within said hollow chamber for forming a circular air slit for expandingly spraying the liquid by injecting compressed air to form the liquid particles in a generally conical shape, a circular liquid slit disposed adjacent to and around said circular air slit for atomizing said liquid, and two pairs of air jet pipes disposed outwardly and rearwardly of said air and liquid slits and in opposed positions with respect to the center of said slits and so directed as to inject air jet streams inwardly and tangentially of the sectional circle of said sprayed liquid particles so as to contact said sprayed stream of liquid particles substantially in the plane of said slits.

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